THE ENGLISH CIRCUMPOLAR EXPEDITION[1]

ON April 14, 1882, I was informed that I was appointed to the command of the Circumpolar Expedition. I at once proceeded to London, and was occupied until the day of sailing in practice with the magnetic instruments at the Kew Observatory, and the purchase of stores, &c., for the expedition.

On May 1 Sergeant F. W. Cooksley, Royal Horse Artillery, and Gunner C. S. Wedenby, Royal Artillery, and on May 6 Sergeant Instructor of Gunnery J. English, R.H.A., reported themselves to me, and commenced attendance at Kew for instruction.

Journey to Fort Rae.—We sailed from Liverpool on May 11, and arrived at Quebec on the 23rd. Here I spent some days, finding that the steamer for the north did not leave Winnipeg till June 10, and my party was very kindly afforded quarters in the citadel by Lieut.-Col. Cotton, commanding the Canadian Artillery at that place.

Having obtained a free pass for our baggage on the Grand Trunk Railway, I started at once for Winnipeg, proceeding by the lakes, that being the cheaper route, and the one which, on the whole, exposed the instruments to the least knocking about.

We reached Winnipeg on June 9, and left on the following day by the *Saskatchewan* steamer. On June 26 we reached Carlton, where it was necessary to engage carts to take our baggage to Green Lake, a distance of 140 miles.

On the 29th the carts were taken across the river, and on the 30th we started for Green Lake, which we reached on July 9, having been delayed by the extreme badness of the road. The heat of the weather also rendered a long halt necessary in the middle of the day, and the flies prevented our animals from feeding properly, incapacitating them for long marches or fast work, and on one occasion forcing us to halt for a whole day, the oxen being so worried by them as to be unable to march.

At Green Lake we entered upon the system of water communication that forms the only roadway in the north, and by way of Portage la Loche, and the Clearwater and Athabasca Rivers, we reached Fort Chipewyan on July 30. Here we had to await the Mackenzie River boats, there being no other means of reaching Fort Rae, and it was not until August 17 that we were able to start on this last stage of our journey. We reached Great Slave Lake on the 22nd, on the evening of which day a gale arose which stove in and sunk our boat, damaging most of our provisions. Fortunately we were able to repair the boat, but it was not until the 25th that the weather allowed us to proceed, and on the 27th we were again detained by a fresh storm, so that it was not until 10 p.m., on August 30, that we arrived at Fort Rae.

Fort Rae.—Fort Rae is situated in lat. 62° 38′ 52″ N., and long. 115° 43′ 50″ W., at the south-west extremity of a peninsula that juts out from the north-east shore of a long gulf running in a north-westerly direction for more than 100 miles from the northern shore of the Great Slave Lake. It is almost entirely surrounded by water, as shown in the annexed plan. The formation is limestone. The land rises to a height of some 200 feet, and it is covered in part with moss, in part with pines and scanty brushwood. A few vegetables are grown in the summer in the garden attached to the Roman Catholic Mission, but for food the inhabitants chiefly depend upon the produce of the nets, and on deer, which are brought in by the Indian hunters attached to the post.

On arrival it was found that the magnetic instruments required a good deal of setting to rights, their boxes being filled with water and the fittings loosened, so that not a single instrument was quite in working order. There was, moreover, no building ready for their reception, so that it was not possible to keep August 31—September 1, as a term day, but we succeeded in getting the meteorological instruments in position so as to commence observations with them at midnight on the 31st.

We were fortunate in finding a building that admitted of conversion into a magnetic observatory, it only requiring a floor, fireplace, door, and windows to be habitable. This work was at once commenced, and on September 3 the declinometer, on the 4th the bifilar, and on the 6th the vertical force magnetometer were mounted in their places. This observatory was finished on September 10, and another one commenced for astronomical and absolute magnetic observations, the continual wind rendering out-door observations unsatisfactory.

[1] "Report on the Circumpolar Expedition to Fort Rae," by Capt. H. P. Dawson, R.A. Communicated to the Royal Society by Prof. G. G. Stokes, Sec. R.S.

The men of my party were accommodated in the house of one of the sub-officers of the fort, and I had a room in the house of the Hudson's Bay Company's officer in charge.

The instruments, on the whole, suffered but little from the journey. One barometer and one thermometer were broken, and the object glasses of the telescopes of most of the magnetic instruments were nearly opaque, the cement joining the two lenses having, from some cause or other, melted on the journey. Our provisions were more damaged, 190 lbs. of sugar, 30 lbs. of tea, all our rice, and most of our baking powder having been destroyed.

The observations were then carried on without interruption until August 31, 1883.

Magnetic Observations.—The balance magnetometer was the only magnetic instrument whose performance was not satisfactory, as not only did it frequently get out of adjustment, but in times of magnetic disturbance it often vibrated through so large an arc that exact reading was impossible. The other instruments were remarkably free from vibration, and there was never any difficulty in reading them, but it was found necessary to extend the scale of the bifilar on the side of decreasing force, owing to the great movements of this instrument.

The greatest magnetic disturbance was on November 17, 18, and 19, 1882, when all the instruments moved at times beyond the limits of their scales. On the first of these days the difference between the extreme easterly and westerly positions of the declinometer magnet exceeded 10°.

Aurora.—Aurora was observed on almost every clear night, and was usually attended by more or less magnetic disturbance. It did not appear to me, however, that the two phenomena stood in the relation of cause and effect, but rather that they were both due to a common cause. The most marked instance of connection between the two phenomena consisted in a rapid decrease in both vertical and horizontal magnetic forces which attended a sudden outburst of aurora in the zenith. This was observed on several occasions. The bifilar almost always showed a reduction of horizontal force during a display of aurora. I also think that the declinometer magnet tended to point towards the brightest part of the aurora, but that (*sic*) I have not yet had time to make that careful comparison of the auroral and magnetic observations which will be required to decide this point. It was found impossible to obtain photographs either of the aurora or of its spectrum—the latter invariably presented the characteristic yellowish green line, and occasionally, but rarely, several other bright lines were visible for a few moments towards the violet end of the spectrum, and once a bright band was seen in the red.

I was also unsuccessful in my attempts to measure the height of the aurora, chiefly from the want of a well defined point to measure to, also from the fact that some hours were required to prepare for this observation, whereas the appearance of a suitable aurora could not be predicted, and was, in fact, not of frequent occurrence, and then often only lasting a few seconds. For this observation two stations some miles apart should be connected by telegraph and occupied for many days, or even weeks, in succession.

Although I paid attention to the point, I never heard any sound from the aurora save on the occasion mentioned in a former memorandum, but I made many inquiries on the subject from residents in the country, both English and French, and their statements agree so well, both with one another and with what I myself heard, that I am forced to conclude that the aurora is at times audible, and that on these occasions it appears to be, and probably is, very near the earth.

Meteorological Observations.—With regard to the meteorological observations, the station was somewhat unfavourably placed for observations of wind, on account of the hill to the north-east, but as winds from this quarter were rare, the effect on the results will not be great, especially as one of the anemometers was on an island in the lake, in an entirely open situation.

The anemometers did not work quite satisfactorily, being at times choked by ice; but I hope by the comparison of the two satisfactory results may be attained.

The wind was usually either south-east or north-west; and when it blew from the former quarter, the motion of the upper clouds often showed the existence of a north-westerly current.

The hair hygrometers were found to be useless out of doors in cold weather, on account of the formation of ice on the hair.

The earth thermometers were read every alternate day: the observations were interrupted by a carcajou, or other animal,

which extracted the thermometers from their tube for the sake of the fur in which it has been found necessary to envelop them, and broke them all; other thermometers were, however, substituted, and the observations continued. It was found impossible to obtain the temperature of the soil at a greater depth than four feet, on account of the rocky nature of the ground.

A series of observations of terrestrial radiation was made by means of a thermometer placed on the surface of the snow, but the almost continual wind detracts much from the value of these readings.

I was told by the residents of the country that the year was an unusually dry one, and certainly the rainfall is remarkably small; they also said that the winter was particularly mild and free from storms, which, from all accounts, and from the journals kept at the fort, seem to be both frequent and severe; as it was, we only experienced one, in February.

Astronomical Observations.—My first determination of the longitude was made by means of lunar distances, and time was found by the method of equal altitudes, but after the observatory was finished both these points were determined by transits, and the first value of the longitude found to be more than a minute in error. The latitude was determined by transit observations in the prime vertical, and is probably within a few seconds of the truth. The longitude may be ten seconds in error. The time was generally correct to within three or four seconds.

A more solidly constructed transit instrument would have been desirable, as it was found that in the cold weather it required so much force to move the telescope of the transit theodolite on its axis that there was great risk of disturbing the adjustments of this instrument, composed as it is of so many parts.

Food, &c.—Our supply of provisions proved quite sufficient. I had brought enough flour to admit of my issuing the usual ration of ¾ lb. per diem, and tobacco 1 lb. per month to each man. We also had a supply of Chollet's preserved vegetables, and a reserve stock of bacon, besides tea and sugar. Of the latter we were somewhat short, owing to the loss sustained on the journey up. We usually had fresh meat throughout the winter; in the summer we were occasionally reduced to dried meat. During the journey there and back we chiefly lived on pemmican. The Rev. Père Roure, of the Roman Catholic Mission, most kindly furnished us with fresh vegetables and potatoes throughout the summer.

The conduct of the men under my command was everything that could be desired. They took great interest in the observations, and did their best to carry them out with accuracy and punctuality, and were always contented and cheerful, in spite of the inevitable discomforts of their winter quarters and the occasional hardships of the journey.

Return Journey.—We were running great risks of being overtaken by the winter, and therefore lost no time in our departure.

The last hourly observation was made at midnight on August 31, 1883, after which the instruments were dismounted and packed, their cases having been previously arranged in readiness outside the observatory. The remainder of the baggage was already in the boat, so that by 2.30 a.m. on September 1 we were *en route*, and reached Fort Chipewyan on September 17, and Portage la Loche on October 4, having experienced some delay in surmounting the rapids of the Clearwater, the hard frosts having frozen all the small tributary streams, thus considerably lowering the water in the river.

The boat awaiting us on the south side of the portage was frozen in, but fortunately the wind changed and the ice broke up before our arrival. Had it been otherwise, we must have waited until the rivers were thoroughly frozen and travelling with dog-trains possible. In that case we should have been compelled to abandon our instruments and baggage.

On the 21st we reached Carlton on the Saskatchewan, where we were detained a day, the man engaged to transport our baggage across the prairie having refused to proceed. Another man was engaged, and on October 31 we reached the railway at Qu'Appelle, arriving at Winnipeg the following day. We were fortunate in crossing the prairie with so little difficulty, as at the same time last year it was covered with three feet of snow.

At Winnipeg I remained a couple of days to adjust accounts with the Hudson's Bay Company, and on November 4 we started for Quebec, going by rail *via* Chicago. We reached Quebec on the 8th, and Liverpool on November 20.

In conclusion, I have to acknowledge the assistance received from the officers of the Hudson's Bay Company, who spared no trouble in carrying out my wishes, especially Chief Commissioner Grahame at Winnipeg, Chief Factors MacFarlane and Camsell in charge of the Athabasca and Mackenzie River Districts respectively, and Mr. King in charge at Fort Rae. To their hearty co-operation the success of the expedition is in great part due.

Results of Expedition.—The following is a list of the observations taken at Fort Rae, the result of our year's work there, which I have now the honour to lay before the Royal Society:—

Magnetic

Hourly—

Declination from September 3, 1882, to August 31, 1883.
Hor. Force ,, 4, ,, ,,
Vert. Force ,, 6, ,, ,,

Term Day—

In accordance with programme laid down by St. Petersburg Conference—from September 15, 1882, to August 15, 1883.

Occasional—

Absolute observations of Hor. Force Dip and Declination.

Meteorological

Hourly—

Barometer from Sept. 1, 1882, to Aug. 31, 1883.
Dry and Wet Bulb Therms. ,, ,, ,,
Anemometer ,, ,, ,,
Wind, Clouds, and Weather ,, ,, ,,
Aurora (when visible) ,, ,, ,,
Hair Hygrometer (when in working order).
Terrestrial Radn. (occasionally in clear weather).

Daily—

Max. and Min. Solar and Terrest. Radn. Therms.
Rain Gauge.

Earth Thermometers every two days.

THE EVIDENCE FOR EVOLUTION IN THE HISTORY OF THE EXTINCT MAMMALIA[1]

II.

COMING to the vertebræ as a part of the osseous system, I will mention the zygapophyses, or antero-posterior direct processes, of which the posterior looks down and the anterior looks up. They move on each other, and the vertebral column bends from side to side. In the lower forms of mammals they are always flat, and in the hoofed mammals of the Puerco period they are all flat. In the Wasatch period we get a single group in which the articulation, instead of being perfectly flat, comes to be rounded; in the later periods we get them very much rounded; and finally, in the latest forms, we get the double curve and the locking process in the vertebral column, which, as in the limb, secures the greatest strength with the greatest mobility. In the first stages of the growth of the spinal cord it is a notochord or a cylinder of cartilage or softer material. In later stages the bony deposit is made in its sheath until it is perfectly segmented.

Now all the Permian land animals, reptiles, and batrachians retain this notochord with the beginnings of osseous vertebræ in a greater or less degree of complexity. There are some in South Africa, I believe, in which the ossification has come clear through the notochord, but they are few. This characteristic of the Permian appears almost alone—perhaps absolutely alone as regards land animals. There is something to be said as to the condition of that column from a mechanical standpoint, and it is this: that the cord exists, its osseous elements disposed about it; and in the batrachians related to the salamanders and the frogs, these osseous elements are arranged under the sheath in the skin of the cord, and they are in the form of regular concave segments, very much like such segments as you will take from the skin of an orange—parts of spheres, and having greater or less dimensions according to the group or species. Now the point of divergence of these segments is on the side of the column. They are placed on the side of the column where the segments separate—the upper segments rising and the lower segments coming downward. To the upper segments are attached the arches and their articulations; and the lower segments are like

[1] A lecture by Prof. E. D. Cope of Philadelphia, given in genera session before the American Association for Advancement of Science at Minneapolis, August 20, 1884. Stenographically reported for *Science*. Continued from p. 230.